CLAIMS

What is claimed is.

1. A process of etching a ball-limiting metallurgy (BLM) stack comprising:

etching a BLM stack disposed over a metallization, in the presence of a nitrogen-containing heterocyclic compound, an ammonium hydroxide compound, an oxidizer, and a metal halide compound.

2. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, and wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state.

3. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, and wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, and wherein the conditions include a pH range from about 7 to about 12.

4. The process according to claim 1, wherein the nitrogen-containing heterocyclic compound is selected from pyrrole, imidazole, oxazole, thizole, pyrazole, 3-pyrroline, pyrrolidine, and n-methyl pyrrolidone.

5. The process according to claim 1, wherein the ammonium hydroxide compound is selected from methyl ammonium hydroxide and tetra methyl ammonium hydroxide.

6. The process according to claim 1, wherein the oxidizer is selected from ozone, hydrogen peroxide, and hydrogen peroxide-containing complexes.

7. The process according to claim 1, wherein the metal halide salt is selected from alkali metal halide salts and alkaline earth metal halide salts.

8. The process according to claim 1, wherein the nitrogen-containing heterocyclic compound includes n-methyl pyrrolidone, wherein the ammonium hydroxide compound includes tetra methyl ammonium hydroxide, wherein the oxidizer includes hydrogen peroxide, and wherein the metal halide compound includes potassium fluoride.

9. The process according to claim 1, wherein the metal stack includes a refractory metal first layer, a lead/tin barrier second layer, a refractory metal third layer, and a nickel-vanadium upper layer, and wherein etching further includes:

etching the nickel-vanadium upper layer in a first etch; and

etching the first-through third layers in the presence of the nitrogen-containing heterocyclic compound, the ammonium hydroxide compound, the oxidizer, and the metal halide compound.

10. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, wherein the nitrogen-containing heterocyclic compound is n-methyl pyrrolidone (NMP), wherein the ammonium hydroxide compound is tetra methyl

ammonium hydroxide (TMAH), wherein the oxidizer is hydrogen peroxide (H_2O_2), wherein the metal halide compound potassium fluoride, and wherein the conditions include NMP:TMAH:H_2O_2 in a volume ratio:

that varies the NMP from about 8:5:2 to about 2:5:2;

that varies the TMAH from about 5:6:2 to about 5:4:2; and

that varies the H_2O_2 from about 5:5:3 to about 5:5:1.

11. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, and wherein the conditions include the metal halide compound that includes potassium fluoride in a range from about 3 gram/liter to about 5 gram/liter.

12. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, and wherein the conditions include maintaining a temperature in a range from about 25° C to about 50° C.

13. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, and wherein the conditions include an etch time in a range from about 30 seconds to about 20 minutes.

14. The process according to claim 1, wherein etching forms a dissolved portion of the metallization, wherein etching is carried out under conditions that retain the dissolved portion of metallization in an oxidized state, and wherein the conditions include:

NMP:TMAH:H_2O_2 in a volume ratio of about 5:5:2;

KF in a concentration of about 4 g/liter;

an etchant temperature of about 40° C; and

an etch time of about 10 minutes.

15. A ball-limiting metallurgy (BLM) etching system comprising:

a substrate including a metallization pad;

a BLM stack including:

a metal first layer disposed above and on the metallization pad;

a metal second layer disposed above and on the metal first layer;

a metal upper layer disposed above the metal second layer;

an electrically conductive bump disposed above and on the BLM stack; and

an etch recipe that includes:

n-methyl pyrrolidone(NMP), tetra methyl ammonium hydroxide (TMAH), hydrogen peroxide (H_2O_2), and potassium fluoride (KF); and

etching conditions that resist dissolving the electrically conductive bump.

16. The BLM etching system according to claim 15, wherein the etching conditions include NMP:TMAH:H_2O_2 in volume ratio ranges from about 8:5:2 to about 2:5:1, from about 5:6:2 to about 5:4:2, and from about 5:5:3 to about 5:5:1.

17. The BLM etching system according to claim 15, wherein the etching conditions include KF in a range from about 3 g/liter to about 5 g/liter.

18. The BLM etching system according to claim 15, wherein the etching conditions include an etching temperature in a range from about 25° C to about 50° C.

19. The BLM etching system according to claim 15, wherein the etching conditions include an etch time in a range from about 30 seconds to about 20 minutes.

20. The BLM etching system according to claim 15, wherein the refractory metal upper layer is selected from a refractory metal, metal-doped refractory metal, or a refractory metal alloy selected from Ni, Co, Pd, Pt, NiV, CoV, PdV, PtV, Ti, Zr, Hf, Cr, Mo, W, Sc, Y, La, and Ce in a solid-solution or stoichiometric ratio.

21. The BLM etching system according to claim 15, wherein the electrically conductive bump comprises a tin-lead solder composition selected from Sn37Pb, Sn97Pb, and Sn_xPb_y, wherein x+y total 1 and wherein x is in a range from about 0.3 to about 0.99.

22. The BLM etching system according to claim 15, further comprising:

a metal third layer disposed above and on the metal second layer, wherein the metal third layer is substantially the same metal as the metal first layer.

23. A ball-limiting metallurgy (BLM) etching system comprising a solution including a nitrogen-containing heterocyclic compound, an ammonium hydroxide compound, an oxidizer, and a metal halide compound, wherein the solution has a pH greater than or equal to about 7.

24. The BLM etching system according to claim 23, wherein the heterocyclic compound includes n-methyl pyrrolidone, wherein the ammonium hydroxide compound includes tetra methyl ammonium hydroxide, wherein the oxidizer includes hydrogen peroxide, and wherein the metal halide compound includes potassium fluoride.

25. The BLM etching system according to claim 23,

wherein the heterocyclic compound includes about five volume parts n-methyl pyrrolidone;

wherein the ammonium hydroxide compound includes about two volume parts 25% tetra methyl ammonium hydroxide in water;

wherein the oxidizer includes about two volume parts 30% hydrogen peroxide in water; and

wherein the metal halide compound includes about 4 gram/liter potassium fluoride in the solution.

26. The BLM etching system according to claim 23, wherein the solution is provided in two parts including:

a first part containing the heterocyclic compound and the oxidizer; and

a second part containing the ammonium hydroxide compound and the metal halide compound.

27. The BLM etching system according to claim 23, wherein the solution is provided in three parts including:

a first part containing the heterocyclic compound;

a second part containing the ammonium hydroxide compound and the metal halide compound; and

a third part containing the oxidizer.